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Filter methods in neutronspectroscopy

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In the last ten years several direct methods of neutronspectroscopy have been developed. (Mechanical and electrical velocityselectors, crystalspectrometers.) In some cases, however, the older indirect methods of filtering are still of interest. Indeed, optical spectroscopy with coloured glasses would be impossible, but it should be mentioned that the absorption bands for slow neutrons are relatively much broader than spectral lines of free atoms and this enables a study of resonance levels without "neutron spectroscopes". Some recent measurements will be described of the width and the positions of resonance levels which were made in Groningen*). To explain the essential features of the method used, we confine ourselves first to the measurement of the shape of the resonance level of Ag. By an Ag absorber a "hole" is made in the energyspectrum of a beam of neutrons. After that this beam is reflected by a scattering substance. The energy loss in the elastic collisions is

$$\Delta E = \frac{2E(1-\cos\varphi)}{A}.$$

In this way the hole in the spectrum is shifted to a lower energy and if ΔE is large enough the intensity of resonance neutrons as detected by a silverfoil may be just as large as if no hole had been made in the spectrum; this depends on the value of ΔE relative to the levelwidth. With decreasing ΔE (increasing A) the activity of the Ag detector decreases and from its dependance on ΔE the shape of the resonance level can be determined. It is essential for the method (which will be called the *displacement method*) that the values of ΔE, given above, happened to be of the order of magnitude of the width of the resonance levels, if we confine ourselves to values of E below 100 eV. The same technique was also used in studies of the overlapping of levels. In that case the detecter and the absorber which made the "hole" were different elements.

*) See Physica **8,** 825 (1941); **10,** 281 (1943); **10,** 299 (1943); **10,** 312 (1943); **10,** 381 (1943); **11,** 345 (1943); **11,** 396 (1946); **11,** 481 (1946); Nature **159,** 569 (1947).

It can be said that at present the resolving power of this method is at least as good as the resolving power of velocity selectors.

Some results are summarised in the tables I, II and in Fig. 1.

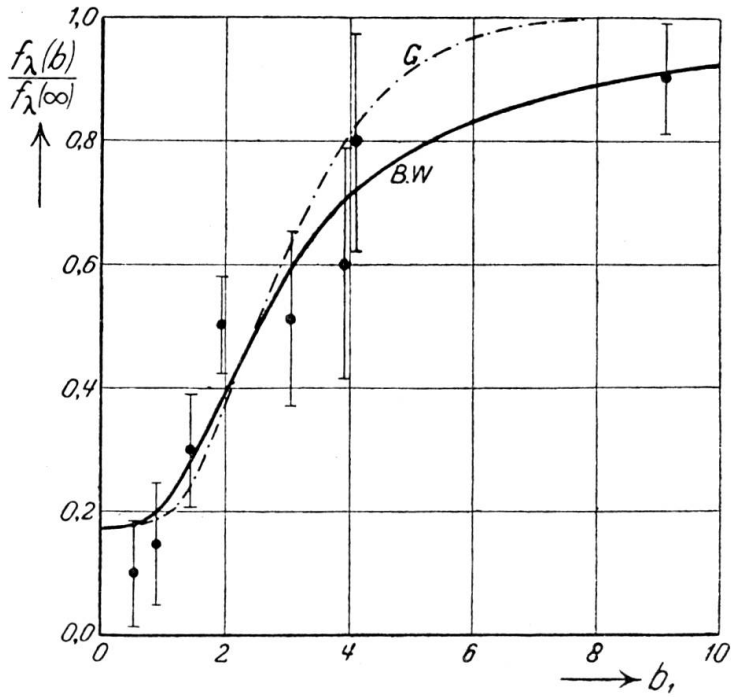

Fig. 1.

Activity of Ag detector as a function of the energy-loss ΔE by the reflecting collision with nuclei of various elements. (b is a parameter proportional to ΔE, containing also Γ. The activity caused by scattered neutrons ($f_\lambda(b)$) is devided by $f_\lambda(\infty)$, the activity which was found when no hole had been made in the spectrum in order to account for the different reflecting powers of the various reflectors. G = curve predicted by a Gaussian form of the resonance level. BW = predicted by the BREIT-WIGNER formula. The value of the level with Γ has already been adjusted to give the best fit.

Table I.

Resonance energies (eV).
Second row: our results (BORON method).
Third row: our results (overlapping).
Fourth row: american reports.

Element	Ag^{108}	Au^{198}	$Ag^{110}_{(a)}$	Sb	$Ag^{110}_{(b)}$	Cd^{117}	Cu^{66}	Cu^{64}	Zn^{69}	Al^{28}
Reson. energy .	23	4.6	5.6		90	110	100	140	500	60
Energy difference		0.31	0.7							
Time of flight .	16	4.8	5.1	5.8						

Table II.

Results of various measurements of the level width Γ.
σ_0 = absorption coefficient for resonance neutrons.
(Time of flight method from american reports.)

Method	Direct experimental result	Results for Ag^{110} (5.1 eV)	Results for Au^{198} (4.8 eV)
1. Displacement method	Γ	0.18	
2. Time of flight . . .	$\sigma_0 \Gamma^2$	0.18	0.15[5]
3. One level formula (BREIT-WIGNER)	$\sigma_0 \Gamma^2$		0.16
4. Activability	$\sigma_0 \Gamma$		0.16[5]
5. Overlapping	$\Gamma, \frac{K_{12}}{K_{11}}, \frac{K_{21}}{K_{22}}$	0.18	0.17